(12) UK Patent Application (19) GB (11) 2 258 277 (13) A

(43) Date of A publication 03.02.1993

(21) Application No 9215534.0

(22) Date of filing 22.07.1992

(30) Priority data
(31) 9116328 (32) 29.07.1991 (33) GB
9121398 09.10.1991

(71) Applicant
European Gas Turbines Limited

(Incorporated in the United Kingdom)

P.O. Box 1, Thorngate House, Firth Road, Lincoln, LN6 7AA, United Kingdom

(72) Inventors
Peter William Hill
John William Hurdle

(74) Agent and/or Address for Service
W P Keppler
The General Electric Company plc, Central Patent Dept (Wembley Office), Hirst Research Centre, Wembley, Middlesex, HA9 7PP, United Kingdom

(51) INT CL^5
F16J 15/32

(52) UK CL (Edition L)
F2B B13CX6

(56) Documents cited
GB 2198195 A

(58) Field of search
UK CL (Edition K) F2B
INT CL^5 F16J

(54) Brush seals

(57) A multi-stage brush seal is for providing a seal at a shaft surface. The seal comprises a number of brushes spaced apart along the shaft (2), each having bristles (1) mounted (8) in cantilever manner and extending radially toward the shaft surface. In addition to the conventional back support plate (3) disposed downstream of the bristles, each brush includes an upstream shield (10). The shield (10) prevents disturbance of the bristles (1) due to turbulent air flow (13) between adjacent brushes, which otherwise tends to displace them and reduce the quality of the seal at the shaft surface. The shield (10) is spaced from the bristles (1) to form a narrow channel (14). Fluid entering the channel (14) through holes (15) in the shield (10) flows radially (17) over the bristles to maintain them in the optimum position and order. Fluid may be injected externally (20, 21) Fig. 4 (not shown) into the channel (14) for improved control of the radial flow (17). The injected fluid (21) is suitably cooling air to assist in reducing the seal temperature.

A plate may be positioned in the channel 14 and biassed against the bristles by a wave spring, Fig. 6 (not shown) to minimise disturbance of the bristles due to the fluid flow. The shield 10 may take the form of a spring plate that also holds the bristles in place, Fig. 5a (not shown).

Fig.3(a).

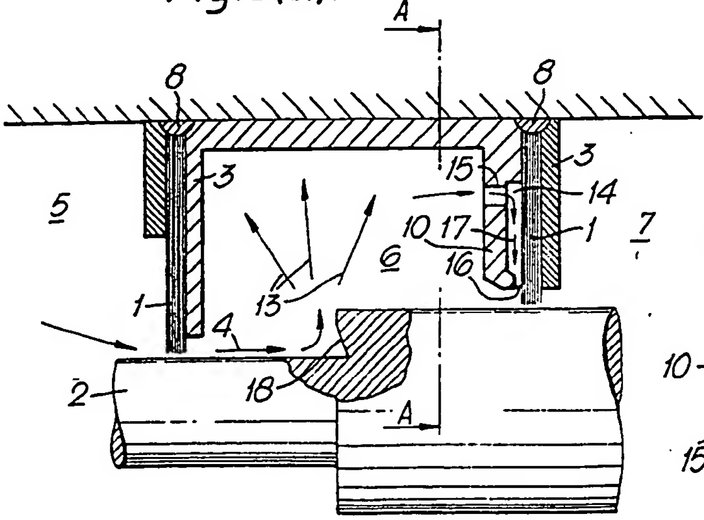
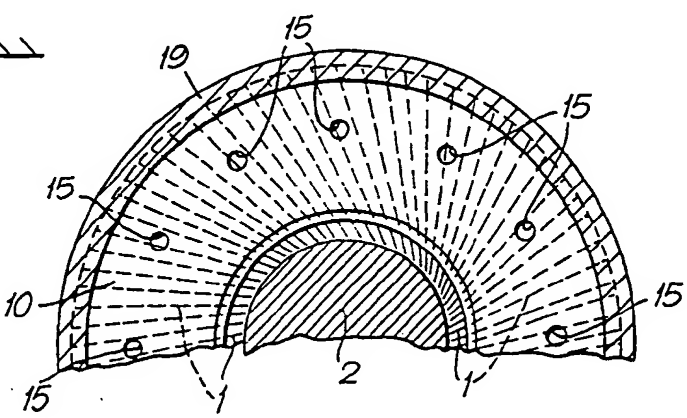


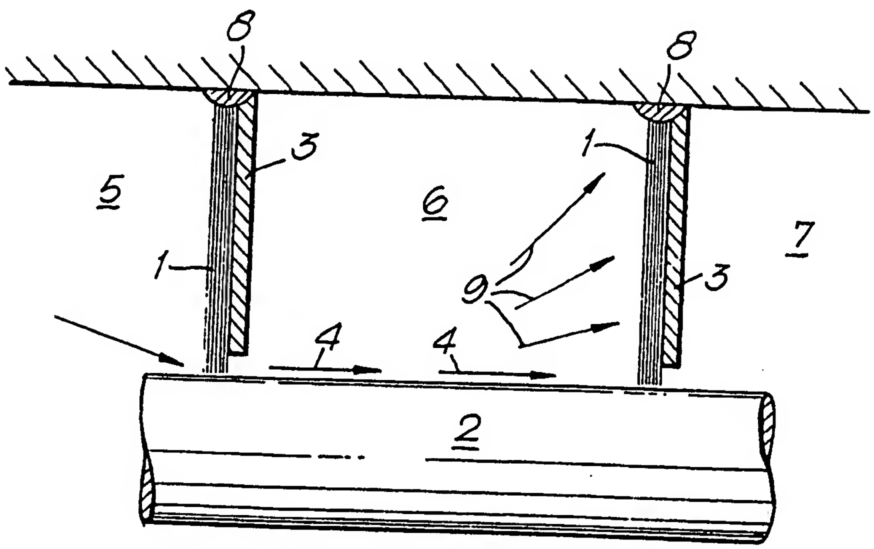
Fig.3(b).



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 258 277 A

Fig. 1.



PRIOR ART

Fig. 2.

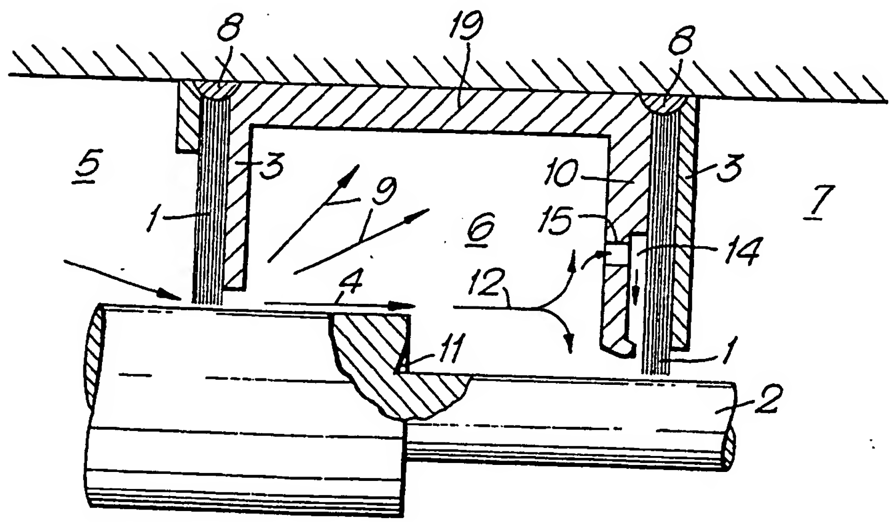


Fig. 3(a).

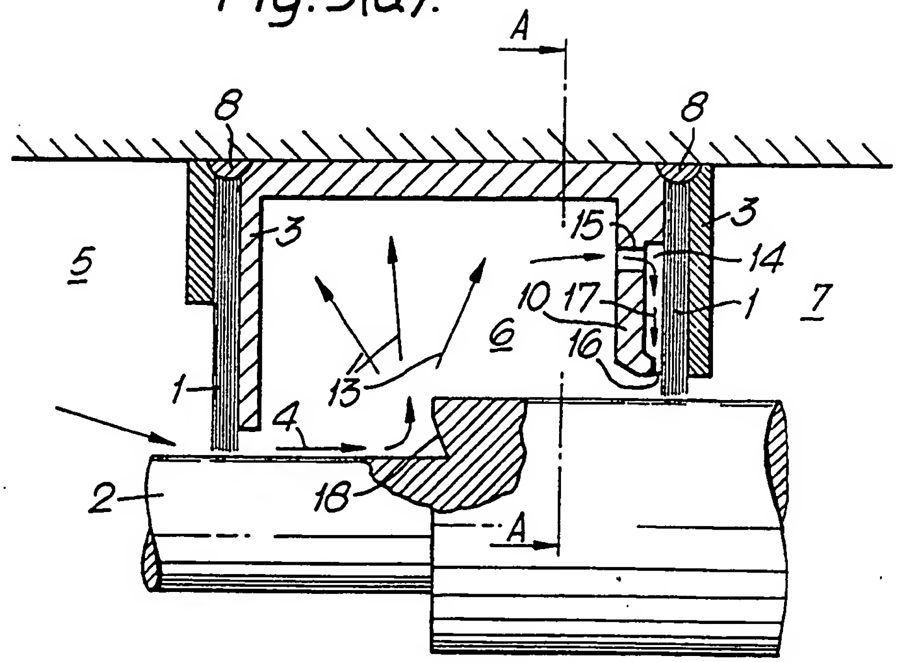


Fig. 3(b).

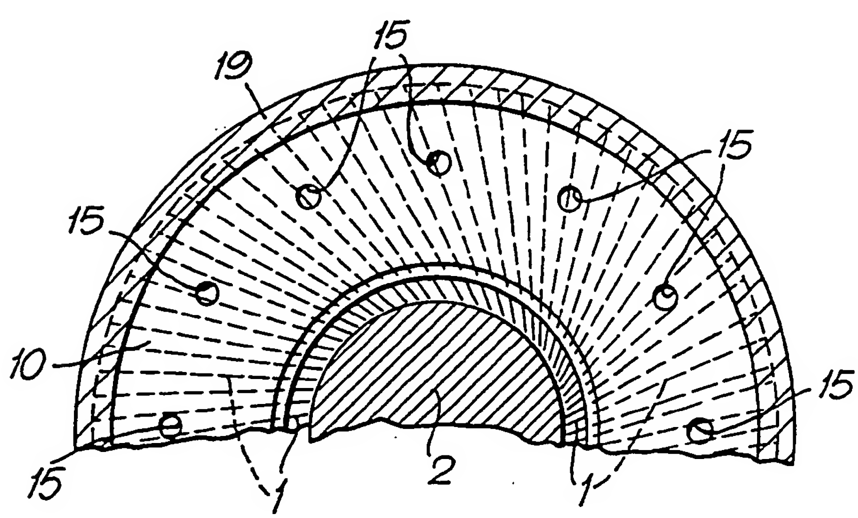


Fig.4.

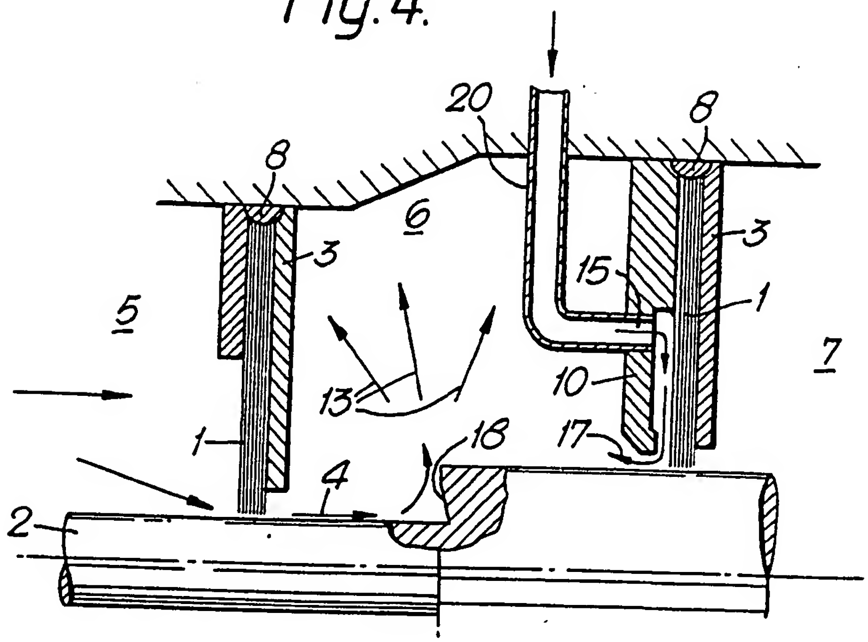


Fig.6.

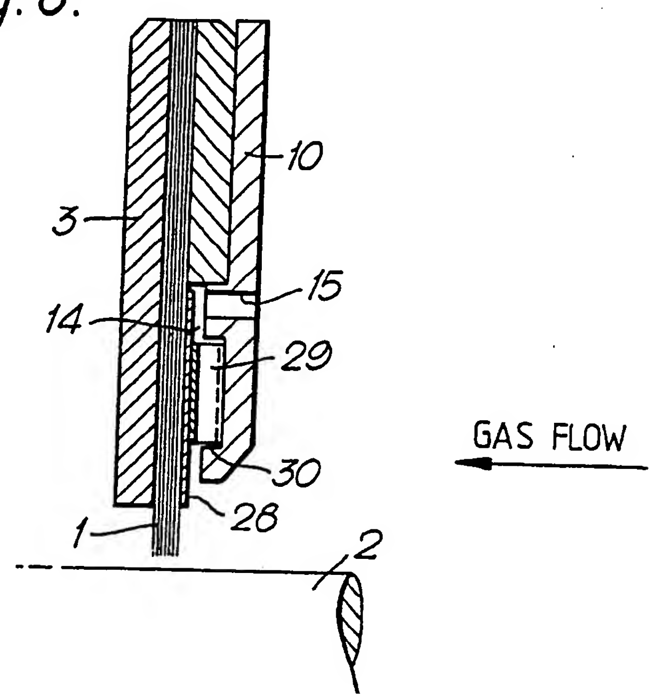


Fig. 5(a).

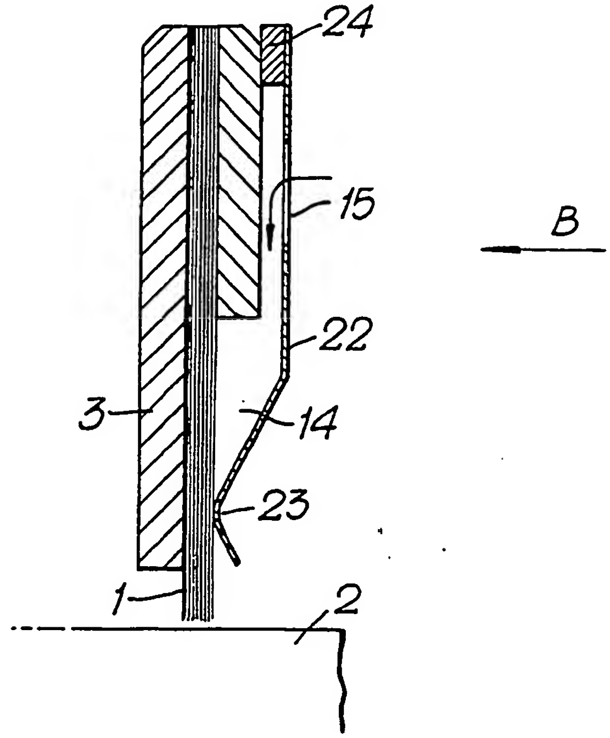
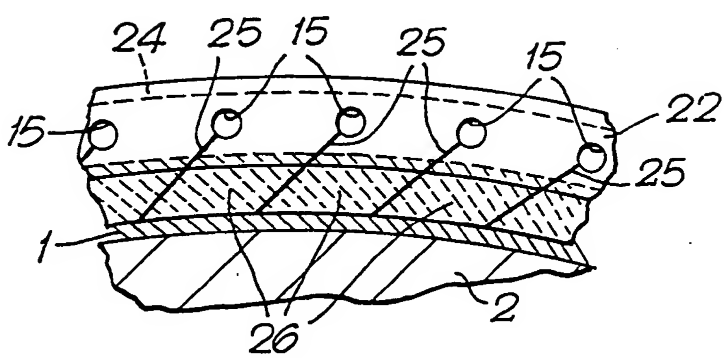


Fig. 5(b).



BRUSH SEALS

This invention relates to brush seals for use in inhibiting fluid flow along a surface. The seals are particularly suitable for providing a seal at the surface of a shaft, but the invention is not so limited.

In a brush seal, if the pressure differential is too great for a single brush to satisfactorily counter, an array of brushes is commonly used to form a multi-stage seal. In this way the total pressure differential is spread over the array, effectively reducing the pressure differential for each seal element. Such a known arrangement is illustrated in section in Figure 1, which shows a shaft seal. Here, only two brushes 1 are shown, the bristles of which are mounted (8) in cantilever manner and extend towards the shaft 2. The bristles are backed by support plates 3 on the downstream side. The brush 1 thus comprises a ring of bristles extending radially with respect to the shaft 2, whilst the support plate 3 is in the form of a disc-like washer loosely surrounding the shaft 2. The arrows 4 indicate the direction of the fluid flow to be countered by the seal, the pressure in the upstream region 5 being higher than the pressure in the region 6 between the two brushes, which, in turn, is higher than the pressure in the downstream region 7.

Experiments have indicated that in such multi-stage seals the bristles of downstream seal elements can become disturbed by the action of the fluid flow between seal elements. It is noted that, after a period of use, the lie of the bristles in the downstream elements is less tidy, there is bristle separation and bending and the bristles have not worn uniformly. Indications are that some bristles are forced by the fluid flow into the gap between the support plate 3 and the shaft 2 and become trapped there.

These disturbances to the bristles appear to arise from at least two components of the fluid flow. One is the turbulent flow (indicated by the arrows 9) which occurs between neighbouring elements and which acts on the downstream bristles to displace them from their optimum 'ordered' arrangement. The second is the high speed fluid jet 4 issuing from the upstream element which remains adjacent and nominally parallel to the shaft 2. This high speed flow is liable to impinge directly on the downstream element at its weakest point, i.e. closest to the shaft where the bristles have no rear support, tending to force the bristle ends into the gap between the support plate and the shaft. Both these aspects of the fluid flow clearly have an effect of the quality on the seal that is obtained.

It is an object of the present invention to provide a brush seal element and a multi-stage brush seal comprising an array of such elements, in which, so far as possible, the aforementioned disturbance of the brush bristles due to fluid flow is minimised.

According to the invention there is provided a brush seal element for use in inhibiting fluid flow along a surface, the element comprising a plurality of bristles mounted in cantilever manner and directed toward the surface, shield means disposed upstream of the bristles and extending from the bristle mounting for the major part of the length of the bristles, said shield means providing a narrow gap between itself and the bristles and having provision for fluid to enter the gap and exit at the free end of the bristles, the seal element further comprising support means

immediately downstream of the bristles and extending from the bristle mounting for a major part of the length of the bristles. The shape of the shield means may be adapted to control fluid flow within the gap. For example, the shield means may provide one or more vanes within the gap.

In one embodiment of the invention, the shield means comprises spring plate means arranged to maintain the bristles in contact with the support means.

In another embodiment, there is included a plate adapted to be located within said gap and spring means disposed between the shield means and the plate to hold the plate in contact with the bristles.

In these last two embodiments disturbance of the bristles by the fluid flow is reduced by the spring force.

In accordance with a preferred embodiment of the invention, a brush seal comprises an array of brush seal elements, each as aforesaid, the elements being spaced apart in the direction of fluid flow. Such a brush seal may be a shaft seal, in which a shaft provides said surface, each seal element providing a ring of bristles around the shaft.

The shield means preferably includes a plurality of said holes, arranged to permit radial fluid flow around the surface of the shaft.

In a shaft seal in which the elements incorporate the aforesaid spring plate means, the spring plate means preferably includes a plurality of slots, each slot extending towards said shaft from a respective one of said holes to permit fluid flow out of said gap.

In a shaft seal in which the elements incorporate the aforesaid spring means, the spring means preferably comprises a wave spring, said plate having the form of a washer which is a loose fit on the shaft. The shield means may have an annular recess adapted to seat the wave spring.

Preferably, the shaft has a surface formation between neighbouring seal elements in the array adapted to deflect fluid flow adjacent the shaft surface. For example, there may be a step change of diameter between neighbouring elements, or the shaft may include an annular collar between neighbouring elements. The step change may be a reduction in diameter so that fluid flow adjacent the shaft surface tends to strike the shield means at a position remote from the shaft.

In a shaft seal in which the shield means incorporates a plurality of holes as aforesaid, there may be included means for injecting fluid into one or more of the holes at a pressure which is greater than the local fluid pressure. The use of injected fluid in this way provides improved control of the radial flow of fluid over the brush bristles. The injected fluid is suitably cooling air to assist in lowering the seal temperature.

In shaft seals as aforesaid the support means of one seal element and the shield means of the next seal element downstream may comprise an integral component.

Several embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows the known multi-stage shaft seal already described;

Figure 2 shows one form of shaft seal in accordance with the invention;

Figures 3(a) and 3(b) show another form of shaft seal in accordance with the invention;

Figure 4 shows a modification of the shaft seal of Figure 3;

Figures 5(a) and 5(b) show an alternative form of seal element, suitable for use in the shaft seal of Figure 3; and

Figure 6 shows a further alternative form of seal element, suitable for use in the shaft seal of Figure 2.

In Figures 2 to 6, components identical with those in the seal of Figure 1 have been given the same references. Referring first to Figure 2, in which again just two brushes 1 are shown by way of illustration, the downstream seal element includes a shield plate 10 disposed immediately upstream of the bristles 1. The shield plate 10 is fixed in relation to the bristle mounting 8. The plate 10 extends from the bristle mounting 8 for a major part of the length of the bristles, terminating, like the rear support plate 3 at a point adjacent the surface of the shaft 2. The effect of the shield plate 10 is to substantially reduce disturbance of the bristles by protecting them from the turbulent fluid flow 9. The gap 14 between the shield plate 10 and the bristles 1, permits fluid flow radially along the bristles so as to tend to keep them aligned. Holes 15 periodically around the shield plate 10 provide access for fluid to the radially outer end of the gap 14. Apart from providing a path for controlled fluid flow, the gap 14 is basically necessary to ensure that the bristles are not clamped between the shield plate 10 and support plate 3.

The shaft 2 has a step reduction 11 in diameter in the fluid flow direction. Whilst this is not essential, it is beneficial in that the high speed fluid flow 4 adjacent the shaft surface at the upstream element, rather than disturbing the bristle ends at the downstream element, tends to strike the shield means at a position remote from the shaft, as indicated by the arrows 12.

Figures 3(a) and 3(b) show a slightly modified version of the shaft seal described above with reference to Figure 2. The shield plate 10 is again shaped so that it is spaced from the bristles 1 along part of the length of the bristles to define the narrow gap 14. The shield plate 10 further includes a plurality of holes 15 (one only being visible in the sectional drawing of Figure 3(a)), which permit fluid flow into the gap 14. Figure 3(b) is a view on line AA in Figure 3(a), in which it can be seen that the holes 15 in the shield plate 10 are spaced apart on a circle so as to permit radial fluid flow around the surface of the shaft 2. This

fluid flow across the face of the bristles, indicated by the arrows 17, produces a smoothing and laying down effect on the bristles which helps to keep them in position. The width of the gap 14 may be reduced at the point 16 where the fluid leaves the gap adjacent the shaft surface to control the fluid flow. The downstream face of the shield plate 10 which defines the gap 14 may also be shaped to control fluid flow within the gap, for instance by the provision of vanes to guide the fluid flow in a direction compatible with the optimum lie of the bristles.

In this embodiment the shaft 2 has a step increase 18 in diameter in the fluid flow direction. This protects the downstream bristle ends from direct impingement by the high speed fluid velocity 4 adjacent the shaft at the upstream element. This high speed flow 4 is deflected by the step 18 as indicated by the arrows 13. Again, whilst this step change in the shaft diameter is not esential, it has a beneficial effect in further reducing disturbance of the downstream bristles. An alternative way of achieving the same effect would be to use a shaft of constant diameter and to provide an annular collar between the neighbouring seal elements. A further alternative, applicable to either the Figure 2 or the Figure 3 embodiment, would be to provide a shallow annular groove in the surface of the shaft, in which the bristles could be seated. This would effectively reduce the disturbing effect of the high speed flow adjacent the shaft surface by preventing any substantial displacement of the bristles from their radially aligned positions.

Figure 4 shows a modification of the shaft seal embodiment described above with reference to Figure 3. Here, the radial fluid flow 17 in the channel 14 between the bristles 1 and the shield plate 10 is provided by fluid 21 injected externally. For this purpose a respective pipe 20 is connected to each, or at least one or more of the holes 15 in the shield plate 10. The injected fluid 21 is at a higher pressure than the local fluid between the two seal elements and may be fed from an upstream (higher pressure) stage of the seal or, more preferably, supplied from an external source.

Injecting fluid in this way provides a greater degree of control in maintaining the bristles in the optimum position and order for a good seal at the shaft surface. If the injected fluid is supplied from an external source, it is advantageously cooling air to assist in lowering the seal temperature. The arrangement of the pipe 20 shown in Figure 4 is clearly equally applicable to other designs of shaft seal, whether of constant shaft diameter (with or without the annular collar described above) or having a step reduction in shaft diameter.

In all the embodiments described above the shield plate 10 and the support plate 3 of neighbouring elements may be linked by a cylindrical wall 19 to form an integral component, as shown for example in Figures 2 and 3.

Figures 5 and 6 illustrate alternative forms of seal element, which are suitable for use in the shaft seals of Figures 3 and 2 respectively.

In the seal element shown in Figure 5(a), the shield plate 10 of Figure 3 comprises a spring plate 22. The plate 22 serves the same function as the plate 10 in reducing disturbance of the bristles 1 by the fluid flow. However, additionally, the spring plate 22 holds the bristles (at the point labelled 23) in contact with the rear support plate 3. It is important to realise that the spring plate 22 is intended to further prevent disturbance of the bristles from their natural, unstressed lie by maintaining a light contact with the bristles at point 23. The effect of this contact is to change the natural frequency of vibration of the bristles. The bristles should not, however, be clamped into a solid pack by the spring plate since this would tend to nullify the inherent sealing qualities of the brush.

As can be seen in Figure 5(b), which is a view on arrow B in Figure 5(a), the spring plate 22 has a disc-like form. The plate 22 is suitably fixed at its outer edge to a mounting ring 24. Preferably, although not essentially, the plate 22 is effectively divided up into a number of smaller plate sections 26 by the

provision of narrow slots 25. Each slot 25 terminates in a hole 15 in the plate and extends to the edge of the plate adjacent the shaft 2. This construction of the plate 22 ensures that each plate section 26 maintains a light contact with the local bristles. A further, secondary, benefit of this plate construction lies in the holes 15 providing entry points for fluid flow into the gap 14 between the plate and the bristles, in the same manner as the holes 15 in the shield plate 10 in the Figure 3 seal. The slots 25 permit fluid to flow out of the gap 14, the radial fluid flow within the gap having the previously described 'settling' effect on the bristles.

The seal element shown in Figure 6 is a development of the one in Figure 2. Here, as in the Figure 5 element, the aim is to maintain a light contact with the bristles to minimise their disturbance by the fluid flow. To this end, Figure 6 shows a plate 28 which is located within the gap 14 between the bristles and the shield plate 10 and is held against the bristles by means of an annular wave spring 29. The plate 28 has the form of a washer which is a loose fit around the shaft 2. It does not extend radially outwards to the bristle mounting but leaves the bristles exposed opposite the holes 15 to permit entry of fluid to the bristles. Three or four locating legs may extend outwardly from the plate 28 to the bristle mounting. Alternatively, the plate 28 may extend fully to the bristle mounting but be perforated to permit fluid access. To facilitate assembly the shield plate 10 is provided with an annular recess 30 in which the wave spring 29 is conveniently seated. It will be understood that, around its circumference, the spring 29 alternately contacts the plate 28 and the shield plate 10, so as to apply a light pressure to the plate 28 over a number of points. In the plane of the sectional view in Figure 6 the spring 29 is shown in contact with the plate 28 at one such point.

It will be appreciated that other forms of spring may be employed. For example, a number of coil springs, seated in respective shallow holes distributed about the shield plate 10, may be used. However, in such an arrangement, to ensure manageable assembly, the individual springs may need to be attached to the shield plate.

Whereas in Figures 2, 3 and 4 only two seal elements are shown by way of illustration, it will be appreciated that a multi-stage brush seal will often comprise an array of three or more elements. However, it will equally be understood that the present invention also embraces a single seal element comprising essentially a brush of bristles, an upstream shield means and a downstream support means.

Whilst the described embodiments are shaft seals, the invention embraces other forms of seals, for example a face-type seal, which in a multi-stage design, may comprise concentrically arranged seal elements.

CLAIMS

1. A brush seal element for use in inhibiting fluid flow along a surface, the element comprising a plurality of bristles mounted in cantilever manner and directed toward the surface, shield means disposed upstream of the bristles and extending from the bristle mounting for the major part of the length of the bristles, said shield means providing a narrow gap between itself and the bristles and having provision for fluid to enter the gap and exit at the free end of the bristles, the seal element further comprising support means immediately downstream of the bristles and extending from the bristle mounting for a major part of the length of the bristles.

2. A brush seal element according to Claim 1, wherein said shield means comprises spring plate means arranged to maintain said bristles in contact with said support means.

3. A brush seal element according to Claim 1, including a plate adapted to be located within said gap and spring means disposed between said shield means and said plate to hold the plate in contact with said bristles.

4. A brush seal element according to any preceding claim, wherein the shape of said shield means is adapted to control fluid flow within said gap.

5. A brush seal element according to Claim 4, wherein said shield means provides one or more vanes within said gap.

6. A brush seal comprising an array of brush seal elements, each according to any one of the preceding claims, the elements being spaced apart in the direction of fluid flow.

7. A shaft seal incorporating an array of brush seal elements according to Claim 6, wherein a shaft provides said surface, each seal element providing a ring of bristles around said shaft.

8. A shaft seal according to any preceding claim, wherein said shield means includes a plurality of said holes, arranged to permit radial fluid flow around the surface of said shaft.

9. A shaft seal according to Claim 8, as appendent to Claim 2, wherein said spring plate means includes a plurality of slots, each slot extending towards said shaft from a respective one of said holes to permit fluid flow out of said gap.

10. A shaft seal according to Claim 7, as appendent to Claim 3, wherein said spring means comprises a wave spring, said plate having the form of a washer which is a loose fit on said shaft.

11. A shaft seal according to Claim 10, wherein said shield means has an annular recess adapted to seat said wave spring.

12. A shaft seal according to any one of Claims 7 to 11, wherein said shaft has a surface formation between neighbouring seal elements in said array adapted to deflect fluid flow adjacent the shaft surface.

13. A shaft seal according to Claim 12, wherein said shaft has a step change of diameter between said neighbouring elements.

14. A shaft seal according to Claim 12, wherein said shaft includes an annular collar between said neighbouring elements.

15. A shaft seal according to Claim 13, wherein said step change is a reduction in diameter so that fluid flow adjacent the shaft surface tends to strike said shield means at a position remote from the shaft.

16. A shaft seal according to Claim 8 or Claim 9, including means for injecting fluid into one or more of said plurality of holes in the shield means at a pressure which is greater than the local fluid pressure.

17. A shaft seal according to Claim 16, wherein, in use, the injected fluid is cooling air.

18. A shaft seal according to Claim 7, wherein the support means of one seal element and the shield means of the next seal element downstream comprise an integral component.

19. A brush seal element substantially as hereinbefore described with reference to any one of Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6 of the accompanying drawings.

20. A shaft seal substantially as hereinbefore described with reference to any one of Figure 2, Figure 3, Figure 4, Figure 2 modified in accordance with Figure 6, and Figure 3 modified in accordance with Figure 5, of the accompanying drawings.

- ...aminer's report to the Comptroller under
...ection 17 (The Search Report)

9215534.0

Relevant Technical fields

(i) UK Cl (Edition K) F2B

(ii) Int Cl (Edition 5) F16J

Databases (see over)

(i) UK Patent Office

(ii)

Search Examiner

R L WILLIAMS

Date of Search

18 AUGUST 1992

Documents considered relevant following a search in respect of claims 1-20

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2198195 A (ROLLS ROYCE)	1

SF2(p)

TP - doc99\fil000259

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1993 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.